Video circuit

The invention relates to a video circuit for processing video signals which show images on a display panel with linear light transition, comprising a gamma correction circuit, a quantizer and a sub-field generator circuit.

From US-PS 6,097,368 is known that video signals for showing images on a display panel of a television set comprise a red, a green and a blue signal, which is 3 times 8 bits of video data. Plasma display panel or PDP for short have a linear light transition. Therefore, the video signals subjected to a gamma function are to be corrected and the video signals converted into luminance data. Plasma display panels are limited as regards the number of luminance stages that can be displayed, a quantization process therefore reduces the number of bits. For generating red, green or blue light for a pixel, sub-fields are addressed which make a red, green or blue light source of the pixel light up for the definite period. This technique is also referred to as sub-field generation or SFG for short. Processors are provided for these methods. The conversion of video signals into luminance signals, the quantization method and the addressing of sub-fields are methods requiring time and implemented successively for a plasma display panel. If a movement occurs from one picture to the next, artefacts may occur.

Therefore it is an object of the invention to save computing time and improve the picture quality.

This object is achieved in accordance with the characteristic features of the co-ordinated claims 1-3.

In a first embodiment, in a first random-access memory a coarse adjustment of the quantization is effected and in a second random-access memory a fine adjustment. Time is saved with the quantization effected in a random-access memory. The splitting up into two parts provides that the necessary memory size for a 12-bit input is significantly reduced.

In a second embodiment most significant bits are quantized in a first random-access memory and least significant bits are quantized in a second random-access memory. Time is saved with the quantization effected in a random-access memory. Here too, the splitting-up into two parts significantly reduces the necessary memory size for a 12-bit input.

In a third embodiment a random-access memory replaces the quantizer. Digital data signals are applied to a random-access memory as addresses and associated values are issued from an output. This saves time compared to a computer that carries out calculations in a plurality of steps.

The random-access memory advantageously replaces a dequantizer. The formerly quantized signal is reconverted and a comparison with the input values can be made. Quantizers and dequantizers are realized in a random-access memory. A quantization error can be detected and an error scattering method can be performed by means of a filter.

The random-access memory advantageously replaces a gamma correction circuit. If a gamma correction function and a quantization are carried out in a single random-access memory, the computing time is also saved. Based on the linear light transition the video signals subjected to a gamma function are to be corrected and video data are converted into luminance data. A corresponding gamma correction function reads $x = y^n$ with $n = 2.4$. In order to achieve a sufficiently high resolution for dark areas, at least 3 times 12 bits are to be used. Plasma display panels are limited as to the number of luminance stages that can be displayed which are typically 32 ($= 2^5$) to 256 ($= 2^8$) discrete stages. A quantization process reduces the number of bits and an error scattering method reduces the occurring quantization noise. The quantization process and the error scattering method are also referred to as dithering.

An inverse gamma correction circuit is advantageously included downstream of the dequantizer. If the correction in the gamma correction circuit is not converted with equidistant values, the inverse gamma correction circuit is necessary between the dequantizer and the filter. The quantizer, the dequantizer, the gamma correction circuit and the inverse gamma correction circuit are then realized in a single random-access memory.

The random-access memory advantageously replaces a sub-field generator. If the quantizer, dequantizer and sub-field generator are collectively realized in a single random-access memory, computer time is also saved.

A gamma function, a quantization, a sub-field generation circuit and a partial line doubling are advantageously achieved by means of two random-access memories. Least significant bits of sub-fields of two neighboring lines are identical and time is saved then. The sub-field generator circuit of a first random-access memory outputs a bit sample with which a plasma display panel can be driven directly and furthermore outputs data via a converter, a quantizer and a filter to the input signal of the neighboring line and via a second converter, a second dequantizer also to the input signal. With sub-fields that are spread non-

equidistantly by the bit sample of the least significant bits is output directly to the quantizer of the second random-access memory.

For a better understanding of the invention, an example of embodiment will be explained hereinafter with reference to the drawing in which:

Fig. 1 shows a block circuit diagram comprising a random-access memory for a quantization process and subsequent dequantization process,

Fig. 2 shows a display panel section with neighboring pixels,

Fig. 3 shows the display panel section with correction values for the neighboring pixels,

Fig. 4 shows a filter with delay elements,

Fig. 5 shows a block circuit diagram with two random-access memories for a coarse and a fine adjustment of a quantization process,

Fig. 6 shows a block circuit diagram with two random-access memories for most significant and least significant bits of a quantization process,

Fig. 7 shows a block circuit diagram with a random-access memory which replaces a gamma correction function and a quantization process for equidistant values,

Fig. 8 shows a block circuit diagram with a random-access memory which replaces a gamma correction function and a quantization process and their reverse functions for non-equidistant values,

Fig. 9 shows a diagram for the representation of quantization noise with a classification in equidistant values,

Fig. 10 shows a diagram for the representation of quantization noise for a classification in non-equidistant values,

Fig. 11 shows a block circuit diagram with a random-access memory which replaces a gamma correction function, a quantizer and their reverse functions and a sub-field generator,

Fig. 12 shows a block circuit diagram for a partial line doubling,

Fig. 13 shows a block circuit diagram with two random-access memories for processing pixel values of a first and a second line for equidistant sub-line codings,

Fig. 14 shows a block circuit diagram with two random-access memories for processing pixel values of a first and a second line for non-equidistant sub-field codings,

Fig. 15 shows a timing diagram with sub-fields for the operation of a plasma display panel and

Fig. 16 shows a second timing diagram with sub-fields for the operation of a plasma display panel in which a partial line doubling is used.

Fig. 1 shows a video circuit 1 having an input 2, a gamma correction circuit 3, an adder 4, a memory 5, a rounding circuit 6, a random-access memory 7, a sub-field generator circuit 8 also called sub-field generation or SFG circuit for short, an output 9 and a filter 10. The memory 7 replaces a multiplier circuit 11, a rounding circuit 12, a second multiplier circuit 13 and an adding circuit 14. The random-access memory 7 is also referred to as allocation table or look-up table, LUT for short. For defined values on m-defined lines the initial values which are present as a result of the functions combined in the memory 7 are calculated and stored in the memory 7.

Fig. 2 shows a display section with neighboring pixels x-1, y-1 and x, y-1 and x+1, y-1 and x-1, y and x, y. Then x is a substitute for the number of the column and y is a substitute for the number of the line.

Fig. 3 shows absolute values by which a quantization error QE which occurs at the respective spot is multiplied for the generation of a value to be displayed for a current value in a pixel x, y. The quantization error, QE for short, is also referred to as quantization noise.

Fig. 4 shows the filter 10 comprising delay elements 15-18 and multiplier elements 19-22 and adders 23, 24, 25. The elements 15, 17 and 18 each delay by one pixel and have a memory location for the value of one pixel, the delay element 16 delays by the number of pixels of one line, subtracts two pixels and accordingly has many memory locations.

The function of the video circuit 1 can be described as follows: in the gamma correction circuit 3 a red, green or blue signal is converted into a red, green or blue luminance signal under the influence of a gamma function. A typical gamma function is non-linear and reads as follows $x = y^n$ with $n = 2.4$. In order to achieve a sufficiently high resolution for dark areas, at least 3 times 12 bits are to be used. The converted red, green or blue luminance signal is applied to the adder 4 over a parallel data line comprising m or 12, respectively, lines. A value ½ from the memory 5 and a further value which is the sum of quantization noise from previous pixels are added to the luminance signal in the adder 4.

With the constant value ½ it is definitely feasible for the rounding circuit 6 to perform a rounding function. The sum of the pixel values preceding the quantization noise is formed in a filter 10, as described in Fig. 4. A luminance value of a pixel value to be displayed is thus calculated as the sum of a current pixel value $X_{(x,y)}$ which is present at input 2 and of the pixel values neighboring the quantization noise values, which neighboring pixel values are calculated in the filter 10 and are added to the current value. The following equation which is satisfied after the rounding circuit 6 is the result thereof:

pixel value to be displayed = rounded ($X_{(x,y)}+1/2 +$
$1/16QE_{(x-1,y-1)}+5/16QE_{(x,y-1)}+3/16QE_{(x+1,y-1)}+7/16QE_{(x-1,y)}$)

with the current pixel value $X_{(x,y)}$.
with the value 1/2 from the memory 5 and
with the values $1/16QE_{(x-1,y-1)}+5/16QE_{(x,y-1)}+3/16QE_{(x+1,y-1)}+7/16QE_{(x-1,y)}$ as a total sum from filter 10.

The quantizer is defined by the following function

$$F(x) = (x / S)$$

where S is the quantization factor that is calculated as follows

$$S = \text{number of input stages} / \text{number of output stages} = 1024 / 256 = 4$$

The dequantization function is predefined by

$$F(y) = y * S$$

The influence on the current pixel value $X_{(x,y)}$ by the filter values is also known as the Floyd-Steinberg algorithm. The random-access memory 7 replaces the two multiplications 11 and 13, the rounding function 12 and the addition 14. This means that for m addresses memory values are available for n outputs to the SFG circuit 8 and m+1-n outputs to the filter 10, which are all in all $2^{m*(m+1)}$ memory locations.

Fig. 5 shows a second video circuit 31 having an input 2, the gamma correction circuit 3, the adder 4, the memory 5, the rounding circuit 6, the SFG circuit 8, the output 9, the filter 10 and a circuit 32. The circuit 32 has a coarse-value random-access memory 33, a fine-value random-access memory 34 and two adders 35 and 36. The coarse-

value random-access memory 33 performs a coarse adjustment in the quantization for the output and the fine-value random-access memory 34 a fine adjustment in the quantization for the output and a feedback loop 37. As a result, the look-up table is split up into two sub-memories 33 and 34 and the necessary memory size is significantly reduced by 0.8 kbyte for a 12-bit input.

Fig. 6 shows a further video circuit 41 having the input 2, the gamma correction circuit 3, the adder 4, the memory 5, the rounding circuit 6, the SFG circuit 8, the output 9, the filter 10 and a circuit 42. The circuit 42 has an MSB random-access memory 43, an LSB random-access memory 44 and two adders 45 and 46. MSB is the abbreviation of most significant bits, thus high-order bits, LSB stands for least significant bits, low-order bits. The input data stream of the parallel data is divided into two halves, where m-k parallel data, which corresponds to m-k parallel lines, flow as MSB into the first memory 43 and 2^{m-k} addresses are detected there. A second half k of parallel data, which corresponds to k parallel lines, flows into the memory 44. A quantization error is further subtracted in the adder 46 from the LSB data.

The function of the circuit 42 is explained for simplicity with values from the decimal system and is as follows:

After the adder 45 the value 41 should be present on the output of circuit 41. In the MSB random-access memory 43 output values for MSB input values are issued in tens, thus in steps of ten and in the LSB random-access memory 44 output values for LSB input values are issued in steps of one. If, however, the MSB memory 43 cannot supply the value 40, but only 39, a quantization error QE occurs on the output of the MSB memory 43, which also flows into the LSB memory 44 via the adder 46. The quantization error would be –1 as absolute value, the addition of the negated value to the LSB value which is 1 is then:

$$LSB - (-1) = LSB + 1 = 2.$$

Thus the necessary memory size is reduced by 0.25 kbyte for a 12-bit input. In this architecture the random-access memory is divided into two parts, one part generates an MSB quantization and an associated quantization error on a first output and the other part generates the LSB quantization and an associated quantization error on a second output. If the two output signals are added together, this will lead to the new quantized value.

The size of the MSB random-access memory is $2^{m/2+(m+1)}$

The size of the LSB random-access memory is $2^{(m+1)/2+(m+1)}$

The contents of the Table can be easily generated with the following algorithm:

Rounded off:

$(X_{(x,y)}+1/2 +1/16QE_{(x-1,y-1)}+5/16QE_{(x,y-1)}+3/16QE_{(x+1,y-1)}+7/16QE_{(x-1,y)})$

X is the value of the newly arriving pixel and QE is the quantization error of previously generated pixel values.

The new quantization output signal is:

Rounded $(1/2_n+1/S^*$
rounded $(X_{(x,y)}+1/2_m+1/16QE_{(x-1,y-1)}+5/16QE_{(x,y-1)}+3/16QE_{(x+1,y-1)}+7/16QE_{(x-1,y)}))$

The new quantization error is:

Rest $(1/2_n+1/S^*$
rounded $(X_{(x,y)}+1/2_m+1/16QE_{(x-1,y-1)}+5/16QE_{(x,y-1)}+3/16QE_{(x+1,y-1)}+7/16QE_{(x-1,y)}))$

Fig. 7 shows a video circuit 51 comprising a random-access memory 52 in which a gamma correction function 53 and a quantization function 54 are combined. The gamma correction function 53 is converted with equidistant values, so that the error spreading in the luminance area is effected by means of a forward controller 55. A current value from the luminance area is added to the filter value from the filter 10 in an adder 57.

Fig. 8 shows a video circuit 61 comprising a random-access memory 62 for values converted with non-equidistant values. The memory 62 replaces a gamma correction circuit 63, a quantizer 64, a dequantizer 65, an inverse gamma correction circuit 66 and an adder 67. Since the gamma-corrected values in the gamma correction circuit 63 have been converted with non-equidistant values, an inverse gamma correction circuit 66 is included in a feedback loop 68. A rounding circuit 69 is inserted between the filter 10 and the adder 4.

Fig. 9 shows a gamma curve 71 which is converted with equidistant values. The result is a quantization noise curve 72 with a high quantization error in a dark area between the absolute values 1 and 22. Especially in dark areas the perception by the human

eye is better than in bright areas. The high quantization error is thus perceived by a viewer. This provides a discrepancy between sampling and perception.

Fig. 10 shows a gamma curve 81 which is sampled with non-equidistant values. The non-equidistant values are shown as curve 82. A quantization noise curve 83 with a rather large quantization noise in a dark area between the absolute values 1 and 22 is smaller than the QE in values converted equidistantly. The first value in the dark area has a small quantization error. In bright areas the quantization noise is larger. The quantization noise in bright areas, however, can be perceived less by a viewer. The sample values thus correspond to the observation.

Fig. 11 shows a video circuit 101 comprising a random-access memory 102 which replaces the gamma correction circuit 63, the quantizer 64, the dequantizer 65, the inverse gamma correction circuit 66, the addition 67 and the sub-field generator 8.

Fig. 12 shows a circuit 111 comprising a line delay 112, a min/max detection circuit 113, a first substitution circuit 114, a partial line doubling circuit 115 and a second substitution circuit 116. The line of a television picture is delayed by one line in the delay circuit 112. Then values of two pixels lying beside each other in one column are compared in the detection circuit 113. The respective larger value is defined and applied to a first or second input of the doubling circuit 115. If the lines are then substituted in the substitution circuit 114, a re-substitution is made in the second substitution circuit 116.

Fig. 13 shows a first partial line doubling circuit 120 for equidistant sub-field codings which circuit can be used for the partial line doubling circuit 115, comprising a first gamma correction circuit 121, an adder 122, an inverse gamma correction circuit 123, a memory 124, a 2D filter 125, a further gamma correction circuit 126, a further adder 127, an inverse gamma correction circuit 128, a further memory 129 and a one-dimensional filter 130. The memory 124 replaces a gamma correction circuit 131, a quantizer 132, an SFG and a PLD circuit 133, a converter 134, a dequantizer 135, a second converter 136, a second dequantizer 137 and an adder 138. The SFG and PLD circuit 133 includes an MSG circuit 139, an LSG circuit 140, an LSG light circuit 141 and a QE circuit 142. The memory 129 replaces a gamma correction circuit 143, a quantizer 144, an SFG and PLD circuit 145, a further converter 146, a dequantizer 147 and an adder 148. The SFG and PLD circuit 145 includes an MSG circuit 149 and a QE circuit 150. Signals are present on inputs 151 and 152 and output signals are output via the outputs 153, 154, 155 and 156. This partial line doubling circuit 120 can be used instead of the partial line doubling circuit 115.

Fig. 14 shows a second partial line doubling circuit 159 for non-equidistant sub-field codings, which circuit 159 can be used instead of the partial line doubling circuit 115, with an adder 160, a memory 161, a 2D filter 162, a further adder 163, a further memory 164 and a one-dimensional filter 165. The memory 161 replaces a gamma correction circuit 166, a quantizer 167, an SFG and PLD circuit 168, a converter 169, a dequantizer 170, an inverse gamma correction circuit 171 and an adder 172. The SFG and PLD circuit 168 includes an MSG circuit 173, an LSG circuit 174 and a QE circuit 175. The memory 164 replaces a gamma correction circuit 176, a quantizer 177, an SFG and PLD circuit 178, a converter 179, a dequantizer 180, an inverse gamma correction circuit 181 and an adder 182. The SFG and PLD circuit 178 includes an MSG circuit 183 and a QE circuit 184. Signals are present on inputs 185 and 186 and output signals are output via outputs 187, 188, 189 and 190.

Fig. 15 shows eight sub-fields 201 to 208, SF for short. Each sub-field has an erasing time 209, an addressing time 210 and a sustaining time 211. The eight sub-fields cover a picture duration 212. The sub-fields 201 to 204 represent least significant bits of a group or LSB for short of a least significant group or LSG for short. The sub-fields 205 to 208 represent most significant bits or MSB of a most significant group or MSG.

If the LSB for two successive lines are identical, there is a time-saving 213 as shown in Fig. 16. The doubling of partial ranges of a line is called partial line doubling in English, PLD for short. Only during the stop period are emitted light pulses from the red, green or blue light sources of a pixel.

The function of the circuit 120 is as follows: pixel values are present on the input of the memory 124 and are converted in the gamma correction circuit 131 into the luminance area, therefore, an 8-bit data word becomes an 12-bit data word to achieve a sufficiently high resolution in dark areas. In the subsequent quantizer the 12-bit data word is adapted to a data word that is necessary for the sub-field generation. The latter data word is applied to the SFG and PLD circuit 133 and an associated bit sample of sub-fields is generated in this circuit.

To avoid artefacts, other sub-fields are addressed in boundary areas than the sub-fields that are responsive of the pixel value to be displayed. A typical example is to address only the sub-field 208 instead of the sub-fields 201 to 207. In addition to the quantizing error an addressing error will then occur. This error is applied by the QE circuit 142 to a converter 134 which converts the light value signal into a luminance signal and eliminates any occurring addressing error. From the converter 134 the signal is conveyed to

the dequantizer 135 which cancels the quantization. The value generated now is compared with the signal from the correction circuit 131 and the actual quantization error is determined in the adder 138. The quantization error is applied to the 2D filter 125 and filtered in accordance with the Floyd-Steinberg algorithm. Since the filtered quantization error is situated in the luminance area and is to be applied to the input signal, the input signal is transformed into the luminance area by the gamma correction circuit 121. This transformation is cancelled in the inverse gamma correction circuit 123.

Since the filtered quantization error also influences pixel values of pixels of the neighboring line, the filter 125 is connected via an electrically conductive line to the adder 127. Thus an output signal of the 2D filter is added for further processing to an input signal which represents pixel values of the neighboring line.

If an addressing error occurs, a respective correction signal is transported from the LSG circuit 141 via the converter 136, the dequantizer 137 to the adder 127 and thus the input signal is corrected which represents pixel values of pixels of the neighboring line.

The video signals in the gamma correction circuit 143 in the memory 129 are transformed from the video area into the luminance area, then quantized in the quantizer 144 and conveyed to an SFG and PLD circuit 145 which generates the bit sample for the sub-fields of the PDP. Only the MSG are generated then. A light value signal is reconverted in the converter circuit 146 into a luminance signal and a possible addressing error is eliminated. The luminance signal is dequantized in the dequantizer 147 and applied to the adder 148. In the adder is determined an actual quantization error and applied to the filter 130. The quantization error has no effect on neighboring lines, so that only a one-dimensional filter 130 is used.

Since here too the processing takes place in the luminance area, the adder 127 is surrounded by a gamma correction circuit 126 and an inverse gamma correction circuit 128 which convert the values of the current pixel of the second neighboring line.

The function of the circuit 159 can be described as follows: pixel values are present on an input 185 of the circuit 159 and are converted into the luminance area in the gamma correction circuit 166 and for this purpose an 8-bit data word becomes a 12-bit data word to achieve a sufficiently high resolution in dark areas. In the subsequent quantizer 167 the 12-bit data word is adapted to a data word that is necessary for the sub-field generation. This data word is applied to the SFG and PLD circuit 168 and in this circuit an associated bit sample of sub-fields is generated which is output via the outputs 187 and 188.

To exclude artefacts, different sub-fields are addressed in boundary areas than the sub-fields that are responsive to the picture value to be displayed. An addressing error then occurs in addition to the quantization error. This addressing error is applied by the QE circuit 175 to a converter 169 which converts the light value signal into a luminance signal and cancels any occurring addressing error. From the converter 169 the signal is conveyed to the dequantizer 170 which cancels the quantization. The downstream inverse gamma correction circuit 171 converts luminance data into video data so that a value in the video area is present on an output of the inverse gamma correction circuit 171, which video area value corresponds to the output value on the outputs 187 and 188. This value is compared in the adder 172 to the input signal and an actual quantization error is determined. The quantization error is filtered in the filter 162 and the actual pixel values of a first line are added to the input 185.

Since the filtered quantization error also influences pixel values of pixels of the neighboring line, the filter 162 is connected to the adder 163 via an electrically conducting line. Thus an output signal of the 2D filter is added to an input signal for further processing which input signal represents pixel values of the neighboring line.

In the memory 164 the video signals in the gamma correction circuit 176 are transformed from the video area to the luminance area, then quantized in the quantizer 177 and conveyed to an SFG and PLD circuit 178 which generates the sub-fields for the PDP. Only the MSG are generated then. In the converter circuit 179 a light value signal is reconverted into a luminance signal and a possible addressing error is eliminated. The luminance signal is dequantized in the dequantizer 180 and applied to the inverse gamma correction circuit 181. In the adder 182 is detected an actual quantization error and this error is applied to the filter 165. The quantization error has no effect on neighboring lines so that only a one-dimensional filter 165 is used.

The LSB on the output 188 are directly applied to the quantizer 177 and are thus taken into account when the most significant bits of the neighboring line available on output 189 are formed.

REFERENCE LIST

1	video circuit	32	circuit
2	input	33	coarse-value random-access memory
3	gamma correction circuit	34	fine-value random-access memory
4	adder	35	adder

5	memory
6	rounding circuit
7	random-access memory
8	sub-field generator circuit
9	output
10	filter
11	multiplier circuit
12	rounding circuit
13	second multiplier circuit
14	adder circuit
15	delay element
16	delay element
17	delay element
18	delay element
19	multiplier element
20	multiplier element
21	multiplier element
22	multiplier element
23	adder
24	adder
25	adder
26	
27	
28	
29	
30	
31	video circuit
36	adder
37	feedback loop
38	
39	
40	
41	video circuit
42	circuit
43	MSB random-access memory
44	LSB random-access memory
45	adder
46	adder
47	
48	
49	
50	
51	video circuit
52	random-access memory
53	gamma correction circuit
54	quantizer
55	forward controller
56	delay element
57	adder
58	
59	
60	
61	video circuit
62	random-access memory

63	gamma correction circuit
64	quantizer
65	dequantizer
66	inverse gamma correction circuit
67	adder
68	feedback loop
69	rounding circuit
70	
71	gamma curve
72	quantization noise curve
73	
74	
75	
76	
77	
78	
79	
80	
81	gamma curve
82	curve
83	quantization noise curve
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101	video circuit
102	random-access memory
103	sub-field generation
104	
105	
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109	
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111	circuit
112	line delay
113	Min/Max detection circuit
114	substitution circuit
115	partial line doubling circuit

85		116	second substitution circuit
86		117	
87		118	
88		119	
89		120	partial line doubling circuit
90		121	gamma correction circuit
91		122	adder
92		123	inverse gamma correction circuit
93		124	memory

125	2D filter	157	
126	gamma correction circuit	158	
127	adder	159	second partial line doubling circuit
128	inverse gamma correction circuit	160	adder
129	memory	161	memory
130	one-dimensional filter	162	2D filter
131	gamma correction circuit	163	adder
132	quantizer	164	memory
133	SG ad PLD circuit	165	one-dimensional filter
134	converter	166	gamma correction circuit
135	dequantizer	167	quantizer
136	converter	168	SFG and PLD circuit
137	second dequantizer	169	converter
138	adder	170	dequantizer
139	MSG circuit	171	inverse gamma correction circuit
140	LSG circuit	172	adder
141	LSG light circuit	173	MSG circuit
142	QE circuit	174	LSG circuit
143	gamma correction circuit	175	QE circuit
144	quantizer	176	gamma correction circuit
145	SFG and PLD circuit	177	quantizer
146	inverse luminance circuit	178	SFG and PLD circuit
147	dequantizer	179	converter
148	adder	180	dequantizer
149	MSG circuit	181	inverse gamma correction circuit
150	QE circuit	182	adder
151	input	183	MSG circuit
152	input	184	QE circuit
153	output	185	input
154	output	186	input
155	output	187	output
156	output	188	output

189	output	221	
190	output	222	
191		223	
192		224	
193		225	
194		226	

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201 sub-field
202 sub-field
203 sub-field
204 sub-field
205 sub-field
206 sub-field
207 sub-field
208 sub-field
209 erasing time
210 addressing time
211 sustaining time
212 duration of image
213 time saving
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